Influence of Quaternary Ammonium Salt Catalysts on Electrical Properties of Epoxy Resins

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Epoxy resins cured with acid anhydride have been widely used for electrical insulating materials because of their excellent electrical and mechanical properties. However, comparing with epoxy resins cured with other hardeners, acid anhydride-cured epoxy resins have lower curing rate and require higher curing temperature. In order to accelerate the curing, it is necessary to add some catalysts. Nevertheless, it has been reported[1] that the catalysts may influence the electrical properties of polymers. We also have found that addition of imidazole catalysts to acid anhydride-cured epoxy resins has evil influence on the dielectric loss and conductivity above the glass transition temperature[2]. In this paper, electrical properties of epoxy resins added with quaternary ammonium salt catalysts that are one of the effective accelerators are discussed. Relationship between electrical properties and the structures of quaternary ammonium salt catalysts is also discussed.

The specimens used in this study are bisphenol-A epoxy resins cured with methyl-tetrahydrophthalic anhydride. Quaternary ammonium salt catalysts used in this study are ammonium chloride(A-Cl), ammonium bromide(A-Br) and ammonium iodide(A-I).

Figure 1 shows relationship between tan δ (at 200℃) and concentration of A-I. It is shown that tan δ increases as the amount of catalysts increases. This suggests that the residual catalyst is the main source of ions.

Figure 2 shows temperature dependence of tan δ of epoxy resins with different catalysts. Concentrations(mol%) of these catalysts are the same. Above 175℃, tan δ increase significantly, which is because of ionic conduction due to the catalysts. However, the enhancement of tan δ is different. Results of conductivity coincide with the results of tan δ. The order of the conductivity is proportional to the size of ions caused by catalysts. It suggests that the difference of conductivity is not attributed to the ion mobility. It is estimated that is attributed to ion concentration due to dissociation of quaternary ammonium salt catalysts. This is supported by the results of thermally stimulated current (TSC) measurement.

In conclusion, addition of quaternary ammonium salt catalysts to acid anhydride-cured epoxy resins has evil influence on electrical properties above the glass transition temperature. The electrical properties of resins are affected by the counter anion of the catalysts.

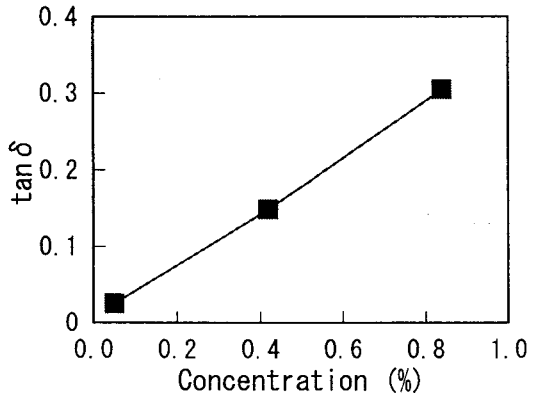

Fig.1 Relationship between tan δ and concentration of A-I.

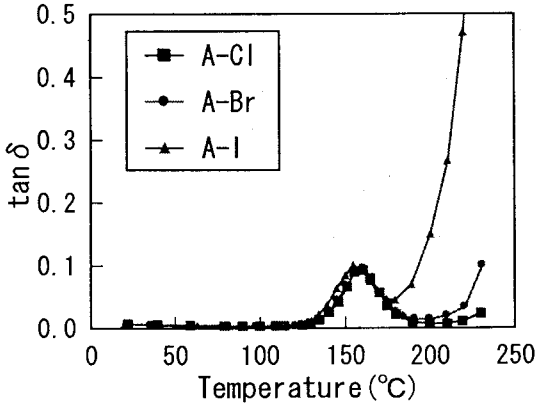

Fig.2 Temperature dependence of tan δ of epoxy resins with different catalysts.

1) J.D.B.Smith, 27th National SAMPE Symposium, 476 (1982)
2) X.H.Yin, T.Kikuchi and H.Fujioka, 1998 International Symposium on Electrical Insulating Materials, 271